U. S. FOREST SERVICE

RESEARCH NOTE NC-32

NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE

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# ANNUAL SOIL TEMPERATURE WAVE AT FOUR DEPTHS IN SOUTHWESTERN WISCONSIN[1]

**ABSTRACT. — Soil temperature was measured for a year on a southeast-facing slope of 25 percent, latitude 43° 50′ N. The spring-summer cover was unmowed alfalfa-bluegrass meadow, the fall-winter cover, meadow stubble. Snow cover was light or absent. The soil was Fayette silt loam, valley phase. The annual temperature wave at all depths followed the air temperature wave. The annual range in soil temperature varied from 30° C. at 15 cm. to 17° C. at 120 cm. The lowest soil temperature was —7° C.**

Temperature of the soil at different depths during different periods of the year is often of interest to research workers in the plant sciences and in watershed hydrology. The interest of hydrologists lies chiefly in soil heat transfer during the winter, when soil freezing may become an important element in the snowmelt-runoff relationship.

Among the important factors (besides latitude and insolation) that affect soil temperature are slope, aspect, and soil cover. The temperature wave for one year under one set of conditions in southwestern Wisconsin (latitude 43° 50′ N.) is presented here.

Temperature was measured by means of thermistors and a resistance bridge. The thermistors were buried at 15-cm. intervals to a depth of 120 cm. in three replications. The site was a southeast-facing slope of about 25 percent on the Coulee Experimental Forest near LaCrosse, Wis. The plant cover, of medium density, was alfalfa meadow interspersed with Kentucky bluegrass. It was mowed and raked in the fall but was left to grow undisturbed in the spring and summer. Snow cover was light or absent during the winter of measurement. The soil was Fayette silt loam, valley phase—a deep, well-drained loessal soil. Readings were made at weekly intervals during late fall and winter (the period of greatest interest to us) and at approximately monthly intervals the rest of the year. The data are for the year beginning with April 1964 and ending with March 1965. All values are means of the three replications.

Although temperature was measured at eight depths, data for only four (30, 60, 90, and 120 cm.) are shown (fig. 1). Readings at the other depths not shown generally fall between the values plotted in figure 1. As would be expected, the readings at 15 cm. showed greater short-term variation.

The annual wave at all depths followed the general shape of the air temperature wave quite closely. The air temperatures plotted in figure 1 are 7-day averages of the mean daily temperature from U.S. Weather Bureau (La Crosse Airport) data. The November rise in soil temperature was caused by a warm spell during the last week of October and the first part of November. Temperature rose at all depths except the two lowest during this period. The low point in the soil temperature wave occurred about a month later than the low in the air temperature wave. Data from St. Paul, Minn., showed a similar lag.[2] The temperature range at a given depth varied from 30° C. at 15 cm. to 17° at 120 cm.

The soil began to freeze during the latter part of December, and by February 8 frost had penetrated to a depth of 75 cm., the lowest depth reached that

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[1] *This research was done in cooperation with the Wisconsin Conservation Department.*

[2] *Baker, Donald G. Factors affecting soil temperature. Minn. Farm and Home Sci. 22: 11-12, illus. 1965.*

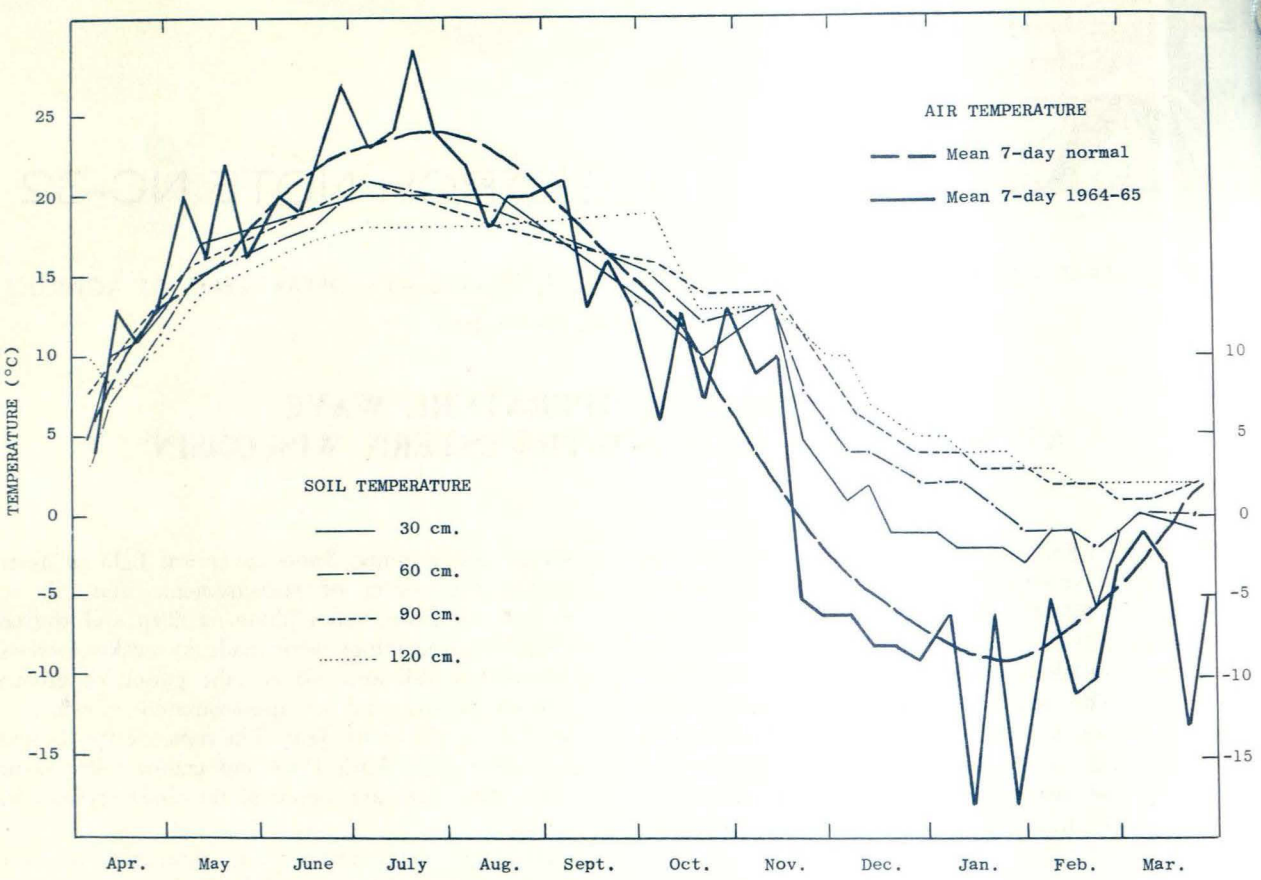


Figure 1.—Air and soil temperatures, April 1964 to March 1965.

*Table 1. — Temperature (°C.) of frozen soil*[1]

| Date | Depth (centimeters) | | | | |
|---|---|---|---|---|---|
| | 15 | 30 | 45 | 60 | 75 |
| 12-21-64 | -1 | -1 | | | |
| 12-28-64 | -1 | -1 | | | |
| 1- 4-65 | -1 | -1 | | | |
| 1-11-65 | -3 | -2 | | | |
| 1-18-65 | -3 | -2 | -2 | | |
| 1-25-65 | -1 | -2 | 0 | 0 | |
| 2- 1-65 | -4 | -3 | -2 | -1 | |
| 2- 8-65 | -1 | -1 | -1 | -1 | -1 |
| 2-15-65 | 0 | -1 | -1 | -1 | -1 |
| 2-23-65 | -7 | -6 | -3 | -2 | -1 |
| 3- 1-65 | 1 | -1 | -1 | -1 | -1 |
| 3- 8-65 | 1 | 0 | 0 | -1 | -1 |
| 3-26-65 | 0 | -1 | 0 | 0 | |
| 4- 5-65 | 1 | 0 | | | |

1/ Blank spaces indicate unfrozen soil.

winter. (An article describing the method of measuring frost depth will be published this year in *Soil Science.)* The soil in the upper 30 cm. of the profile was continuously frozen from December 21 through March; yet its temperature varied from 1° to —7° C. (table 1). Temperature of the soil below the frost line diminished gradually to a minimum of about 1° C. at the end of February (fig. 1).

This information will help guide our research on how land use and slope climate affect the depth, type, and incidence of soil freezing — all key factors to springtime floods and ground water accretion in the Upper Midwest's unglaciated region.

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